



分析与微分方程研讨会 会议手册

主办：苏州大学
协办：上海交通大学

2021年11月20日-22日

目录

1 基本信息	2
2 日程安排	4
2.1 第一天: 11-20(周六)	4
2.2 第二天: 11-21(周日)	4
2.3 第三天: 11-22(周一)	5
3 摘要	6
3.1 第一天: 11-20(周六)	6
3.2 第二天: 11-21(周日)	8
3.3 第三天: 11-22(周一)	10

1 基本信息

简介

为促进现代分析与微分方程及相关学科的专家、学者介绍交流研究领域的新进展和新动向，加强彼此之间的相互了解与合作，以便更好地了解现代分析与微分方程相关领域的前沿热点问题、相关应用以及最新研究成果。由苏州大学与上海交通大学于 2021 年 11 月 20 日-22 日在线上举办“分析与微分方程研讨会”。

时间

2021 年 11 月 20 日-11 月 22 日

线上会议—腾讯会议

2021 年 11 月 20 日:

会议 ID: 810-798-667

密码: 211120

2021 年 11 月 21 日:

会议 ID: 215-753-229

密码: 211121

2021 年 11 月 22 日:

会议 ID: 978-862-380

密码: 211122

会议组委会

- 辛周平，香港中文大学
- 曹永罗，苏州大学
- 赵云，苏州大学
- 王云，苏州大学
- 谢春景，上海交通大学

主办、协办单位

- 主办单位：苏州大学
- 协办单位：上海交通大学

资助单位

- 苏州大学数学科学学院
- 苏州大学动力系统与微分方程研究中心

- 国家自然科学基金委
- 上海交通大学数学科学学院
- 上海交通大学自然科学研究院
- 科学与工程计算教育部重点实验室
- 上海市现代分析前沿科学研究基地

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2 日程安排

2.1 第一天: 11-20(周六)

时间	报告人	题目	主持人
08:40 - 09:00		开幕式	
09:00 - 09:45	程崇庆	Residues of destructed resonant torus	辛周平
09:45 - 10:00		Tea Break	
10:00 - 10:45	庾建设	Mosquito suppression models consisting of two sub-equations switching each other	赵会江
10:45 - 11:30	王晓明	Thermal convection in superposed free flow and porous media: analysis and numerics	江松
11:30 - 14:15		Lunch Time	
14:15 - 15:00	罗涛	On the Free Boundary Problem of 3-D Full compressible Euler Equations Coupled with a Non-linear Poisson Equation	邓引斌
15:00 - 15:45	章志飞	Linear inviscid damping and enhanced dissipation for monotone shear flows	王维克
15:45 - 16:00		Tea Break	
16:00 - 16:45	尹会成	On the global existence or blowup of smooth large data solutions to the second order quasilinear wave equations	朱长江
16:45 - 17:30	徐霄乾	Suppression of explosion by mixing	丁时进

2.2 第二天: 11-21(周日)

时间	报告人	题目	主持人
09:00 - 09:45	朱熹平	Gradient estimates for harmonic maps into singular spaces	楼元
09:45 - 10:00		Tea Break	
10:00 - 10:45	杨彤	Analysis on Tollmien-Schlichting wave in the Prandtl-Hartmann Regime	王亚光
10:45 - 11:30	王学锋	Derivation of a field-road model	杨孝平
11:30 - 14:15		Lunch Time	
14:15 - 15:00	李从明	Analysis of steady solutions for the incompressible Euler system in an infinitely long nozzle	尹景学
15:00 - 15:45	杜力力	The Bernoulli-type free boundary problem and its application	谭忠
15:45 - 16:00		Tea Break	
16:00 - 16:45	黄飞敏	Continued gravitational collapse for gaseous star and pressureless Euler-Poisson system	屈长征
16:45 - 17:30	王海涛	1-D Navier-Stokes equation with BV data: well-posedness and wave propagation	李亚纯

2.3 第三天: 11-22(周一)

时间	报告人	题目	主持人
09:00 - 09:45	吕克宁	Statistical properties of 2D Navier-Stokes equations with time periodic forcing and degenerate stochastic forcing	曹永罗
09:45 - 10:00		Tea Break	
10:00 - 10:45	曹道民	不可压缩欧拉方程的涡解	陈化
10:45 - 11:30	徐润章	Global well-posedness of coupled parabolic systems	李海梁
11:30 - 14:15		Lunch Time	
14:15 - 15:00	琚强昌	Low Mach number limit of Navier-Stokes equations with large temperature variations in bounded domains	王术
15:00 - 15:45	吴俊德	A free boundary problem modeling tumor growth with Gibbs-Thomson relation	李竞
15:45 - 16:00		Tea Break	
16:00 - 16:45	王春朋	Smooth sonic-supersonic flows in critical nozzles	徐超江
16:45 - 17:30	张立群	The blow up solutions to Boussinesq equations on R^3 with dispersive temperature	姚正安

3 摘要

3.1 第一天: 11-20(周六)

Residues of destructed resonant torus

程崇庆, 南京大学
09:00 - 09:45

In this talk, we introduce a method to handle the problem of complete degeneracy in the study of lower dimensional invariant tori surviving from destructed resonant torus.

Mosquito suppression models consisting of two sub-equations switching each other

庾建设, 广州大学
10:00 - 10:45

The release of Wolbachia-infected mosquitoes in 2016 and 2017 enabled near-elimination of the sole dengue vector *Aedes albopictus* on Shazai and Dadaosha islands in Guangzhou. Mathematical analysis may offer guidance in designing effective mass release strategies for the area-wide application of this Wolbachia incompatible and sterile insect technique in the future. The two most crucial questions in designing release strategies are how often and in what amount should Wolbachia-infected mosquitoes be released in order to guarantee the success of population suppression. In this talk, I will introduce our recent works on answering the two questions which have been published in the following three papers.

- J. Differ. Equations, 2020, 269(7): 6193-6215.
- J. Differ. Equations, 2020, 269(12): 10395-10415.
- SIAM J. Appl. Math., 2021, 81(2): 718-740.

By treating the released mosquitoes as a given function, we proposed mosquito suppression models consisting of two sub-equations switching each other. An almost complete characterization of interactive dynamics of wild and released mosquitoes are offered, including the global asymptotic stability of zero solution and the exact number of periodic solutions of these models. It is well known that to obtain existence and also uniqueness conditions for periodic solutions is mathematically challenging for many dynamical systems and there are few such results existed. I hope the methods and techniques used in these three papers can be usefully applied to other model analysis as well.

Thermal convection in superposed free flow and porous media: analysis and numerics

王晓明, 南方科技大学
10:45 - 11:30

We report on a few recent results related to thermal convection in a fluid layer overlying a saturated porous media based on the Navier-Stokes-Darcy-Boussinesq (NSDB) model with appropriate interface boundary conditions. The existence of global in time weak solution for the NSDB system together with a weak-strong uniqueness result are presented first. The stability

of the pure conduction state at small Rayleigh number is introduced next. The loss of stability of the pure conduction state as the Rayleigh number crosses a threshold value is studied via a hybrid approach that combines analysis with numerical computation. In particular, we discover that the transition between shallow and deep convection associated with the variation of the ratio of free-flow to porous media depth is accompanied by the change of the most unstable mode from the lowest possible horizontal wave number to higher wave numbers, which could occur with variation of the height ratio as well as the Darcy number and the ratio of thermal diffusivity among others. Numerical methods that decouples the heat, the free flow, the porous media flow while maintaining energy stability are presented as well.

On the Free Boundary Problem of 3-D Full compressible Euler Equations Coupled with a Nonlinear Poisson Equation

罗涛，香港城市大学
14:15 - 15:00

For the problem of full compressible Euler Equations with variable entropy coupled with a nonlinear Poisson equation in three spatial dimensions with a general free boundary not restricting to a graph, we identify a stability condition for the electric potential of which the outer normal derivative is positive on the free surface besides the Taylor sign condition for the pressure to obtain a priori estimates on the Sobolev norms of the fluid variables and bounds for geometric quantities of free surface. This talk is based on a joint work with K. Trivisa and H. Zeng.

Linear inviscid damping and enhanced dissipation for monotone shear flows

章志飞，北京大学
15:00 - 15:45

In this talk, we will introduce a compactness method to establish the linear inviscid damping and enhanced dissipation estimates for the 2-D linearized Navier-Stokes system around a class of monotone shear flows in a finite channel. These estimates should be crucial for nonlinear stability.

On the global existence or blowup of smooth large data solutions to the second order quasilinear wave equations

尹会成，南京大学
16:00 - 16:45

In this talk, for the second order quasilinear wave equations with the short pulse initial data (a class of large initial data which are firstly introduced by D.Christodoulou), we shall discuss the sufficient and necessary conditions for the global existence or blowup of smooth solutions. These works are joint with Prof.Xin Zhouping and Prof.Ding Bingbing.

Suppression of explosion by mixing

徐霄乾，昆山杜克大学
16:45 - 17:30

In the study of incompressible fluid, one fundamental phenomenon that arises in a wide variety of application is dissipation enhancement by so-called mixing flow. In this talk, I will give a brief introduction to the idea of mixing flow and the role it plays in the field of advection-diffusion-reaction equation. More specifically, I will explain why the presence of fluid can enhance the dissipation and prevent the singularity formation for some types of evolution equations, even with degeneracy.

3.2 第二天: 11-21(周日)

Gradient estimates for harmonic maps into singular spaces

朱熹平, 中山大学
09:00 - 09:45

In his seminal work in geometric analysis, S. T. Yau proved the famous gradient estimate for harmonic functions on smooth manifolds. Later in 1980, S. Y. Cheng extended the Yau's gradient estimate to harmonic maps between smooth manifolds. In this talk we will discuss the question how to obtain Yau's gradient estimates for harmonic maps from smooth manifolds to singular metric spaces.

Analysis on Tollmien-Schlichting wave in the Prandtl-Hartmann Regime

杨彤, 香港城市大学
10:00 - 10:45

In this talk, we will present the instability induced by the Tollmien-Schlichting wave governed by the MHD system in the Prandtl-Hartmann regime. The interaction of the inviscid mode and viscous mode that leads to the instability is analyzed by the introduction of a new decomposition of the Orr-Sommerfeld operator on the velocity and magnetic fields. The critical Gevrey index for the instability is justified by constructing the growing mode in the essential frequency and it is shown to be the same as the incompressible Navier-Stokes equations in the Prandtl regime. This result justifies rigorously the physical understanding that the transverse magnetic field to the boundary in the Prandtl-Hartmann regime has no extra stabilizing effect on the Tollmien-Schlichting wave. This is a joint work with Chengjie Liu and Zhu Zhang.

Derivation of a field-road model

王学锋, 香港中文大学 (深圳)
10:45 - 11:30

Of concern is the scenario of a road running through a large field, in which a diffusive species has different diffusion rates on the road and in the field, respectively. 8 years ago, Berestycki and collaborators proposed a field-road model, which consists of the KPP equation for the areal density function in the field, and a reaction-diffusion equation for the linear density function on the road (the x-axis), with the two density functions coupled by a Robin boundary on the x-axis. We wonder if this model can be derived from a more basic model. Indeed, we do so by first assuming the width of the road is positive, and then proposing a full model on the

whole plane, with reasonable transmission conditions on the edges of the road, we then send the width of the road to 0. The resulting limiting model covers the field-road of Beresticky et al, and more. This is a joint work of Haomin Huang, Siyu Liu and Yantao Wang.

Analysis of steady solutions for the incompressible Euler system in an infinitely long nozzle

李从明，上海交通大学
14:15 - 15:00

Stagnation point in flows is an interesting phenomenon in fluid mechanics. It induces many challenging problems in analysis. This talk presents a recent joint work with Yingshu Lv and Chunjing Xie. We first derive a Liouville type theorem for Poiseuille flows in the class of incompressible steady inviscid flows in an infinitely long strip, where the flows can have stagnation points. With the aid of this Liouville type theorem, we show the uniqueness of solutions with positive horizontal velocity for steady Euler system in a general nozzle when the flows tend to the horizontal velocity of Poiseuille flows at the upstream. Finally, this kind of flows are proved to exist in a large class of nozzles.

The Bernoulli-type free boundary problem and its application

杜力力，四川大学
15:00 - 15:45

In this talk, we will introduce the mathematical theory on the Bernoulli' s type free boundary problem, including the existence and uniqueness of the solution to the free boundary problem and the regularity of the free boundary. Moreover, as an important application of this theory, we will introduce the recent existence results on the steady incompressible inviscid impinging jets with gravity.

Continued gravitational collapse for gaseous star and pressureless Euler-Poisson system

黄飞敏，中国科学院数学与系统科学研究院
16:00 - 16:45

The gravitational collapse of an isolated self-gravitating gaseous star for γ -law pressure $p(\rho) = \rho^\gamma$ ($1 < \gamma < \frac{4}{3}$) in the mass-supercritical case is investigated. In this talk, all spherically symmetric solutions of the pressureless Euler-Poisson system are classified. Precisely speaking, for fixed radius r , there exists a unique critical velocity $v^*(r) > 0$ depending on the mean density in the ball $B(0, r)$ for the pressureless Euler-Poisson system such that if the initial velocity $\chi_{-1}(r) \geq v^*(r)$ (Escape case), then the dust runs away from the gravitational force forever along an escape trajectory, and if the initial velocity $\chi_{-1}(r) < v^*(r)$ (Collapse case), then the dust collapses at the origin in a finite time $t^*(r)$ even it expands initially, i.e., $\chi_{-1}(r) > 0$. Moreover, it is proved that there exist a class of spherically symmetric solutions of gaseous star, which formulate a continued gravitational collapse in finite time, based on the background of the pressureless solutions if $\chi_{-1}(r) < v^*(r)$ for all $r \in [0, 1]$. It is noted that

$\chi_1(r)$ could be positive, that is, the star might expand initially, but finally collapse. The talk is based on a joint work with Yue Yao.

1-D Navier-Stokes equation with BV data: well-posedness and wave propagation

王海涛, 上海交通大学
16:45 - 17:30

It is established recently by Liu-Yu a constructive existence theory of weak solution to isentropic Navier-Stokes equation with initial data of small total variation. The key ingredient in their work is the pointwise structures of heat kernel with BV coefficient. In this talk, we will first review their result. Then, by refining the heat kernel estimates, we prove the regularity and uniqueness of the weak solution. Moreover, if the initial perturbation in BV class is localized in space, we can describe the wave propagation precisely. This talk is based on joint works with Shih-Hsien Yu and Xiongtao Zhang.

3.3 第三天: 11-22(周一)

Statistical properties of 2D Navier-Stokes equations with time periodic forcing and degenerate stochastic forcing

吕克宁, *Brigham Young University* & 四川大学
09:00 - 09:45

We consider the incompressible 2D Navier-Stokes equations with periodic boundary conditions driven by a deterministic time periodic forcing and a degenerate stochastic forcing. We show that the system possesses a unique ergodic periodic invariant measure which is exponentially mixing under a Wasserstein metric. We also prove the weak law of large numbers for the continuous time inhomogeneous solution process. In addition, we obtain the weak law of large numbers and central limit theorem by restricting the inhomogeneous solution process to periodic times. The results are independent of the strength of the noise and hold true for any value of viscosity with a lower bound ν_1 characterized by the Grashof number G_1 associated with the deterministic forcing. In the laminar case, there is a larger lower bound ν_2 of the viscosity characterized by the Grashof number G_2 associated with both the deterministic and random forcing. We prove that in this laminar case, the system has trivial dynamics for any viscosity larger than ν_2 by demonstrating the existence of a unique globally exponentially stable random periodic solution that supports the unique periodic invariant measure.

不可压缩欧拉方程的涡解

曹道民, 中国科学院数学与系统科学研究院 & 广州大学
10:00 - 10:45

报告人将报告近年来在不可压欧拉方程定常涡解方面的研究, 特别地要介绍在二维全空间中不可压欧拉方程行波涡对解 (traveling vortex pair)、涡线对 (vortex sheet) 的存在性和带边界二维区域上不可压欧拉方程定常涡线解的存在性。

报告人介绍的结果主要来源于和赖善发、秦国林、詹伟城、邹昌君合作的论文。

Global well-posedness of coupled parabolic systems

徐润章, 哈尔滨工程大学
10:45 - 11:30

The initial boundary value problem of a class of reaction-diffusion systems (coupled parabolic systems) with nonlinear coupled source terms is considered in order to classify the initial data for the global existence, finite time blowup and longtime decay of the solution. The whole study is conducted by considering three cases according to initial energy: low initial energy case, critical initial energy case and high initial energy case. For the low initial energy case and critical initial energy case the sufficient initial conditions of global existence, long time decay and finite time blowup are given to show a sharp-like condition. And for the high initial energy case the possibility of both global existence and finite time blowup is proved first, and then some sufficient initial conditions of finite time blowup and global existence are obtained respectively.

Low Mach number limit of Navier-Stokes equations with large temperature variations in bounded domains

琚强昌, 北京应用物理与计算数学研究所
14:15 - 15:00

The low Mach number limit of full compressible Navier-Stokes equations with large temperature variations is verified rigorously in a three-dimensional bounded domain. Weighted uniform estimates of the solutions are derived delicately in a time interval which is independent of the Mach number, in particular, for the high-order derivatives, when the initial data are well prepared only in the sense of L²-norm. The effects of large temperature variations and solid boundaries create some essential difficulties in showing the uniform estimates. This is a recent joint work with Prof. Ou, Yaobin from Renmin University.

A free boundary problem modeling tumor growth with Gibbs-Thomson relation

吴俊德, 苏州大学
15:00 - 15:45

In this talk, we discuss well-posedness and asymptotic behavior of a FBP tumor model with Gibbs-Thomson relation. The tumor model consists of a diffusion equation for the nutrient concentration and an elliptic equation for the pressure, and the movement of the tumor boundary satisfies the kinematic condition.

Smooth sonic-supersonic flows in critical nozzles

王春朋, 吉林大学
16:00 - 16:45

This talk concerns the global existence of smooth sonic-supersonic potential flows in a two-dimensional expanding nozzle with the critical geometry at the inlet. The flow is governed by a quasilinear non-strictly hyperbolic equation with degeneracy at the inlet. An interesting

phenomena is that the existence of such sonic-supersonic flows depends on the height of the inlet.

The blow up solutions to Boussinesq equations on R^3 with dispersive temperature

张立群，中国科学院数学与系统科学研究院
16:45 - 17:30

The three-dimensional incompressible Boussinesq system is one of the important equations in fluid dynamics. The system describes the motion of temperature-dependent incompressible flows. And the temperature naturally has diffusion. Very recently, Elgindi, Ghoul and Masmoudi constructed a $C\{1, \alpha\}$ finite time blow up solutions for Euler systems with finite energy. Inspired by their works, we constructed $C\{1, \alpha\}$ finite time blow-up solution for Boussinesq equations where temperature has diffusion and finite energy. The main difficulty is that the Laplace operator of temperature equation is not coercive under Sobolev weighted norm which is introduced by Elgindi. We introduced a new time scaling formulation and new weighted Sobolev norms, under which we obtain the coercivity estimate. The new norm is well-coupled with the original norm, which enable us to finish the proof.

This is a jointed work with Gao Chen and Zhang Xianliang.